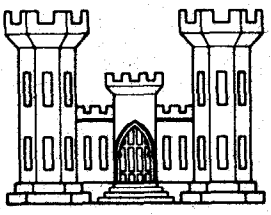
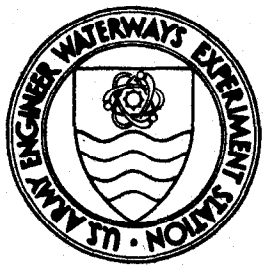


DREDGED MATERIAL RESEARCH PROGRAM



MISCELLANEOUS PAPER D-75-13

GENERAL RESEARCH PLAN FOR THE FIELD INVESTIGATIONS OF COASTAL DREDGED MATERIAL DISPOSAL AREAS

by

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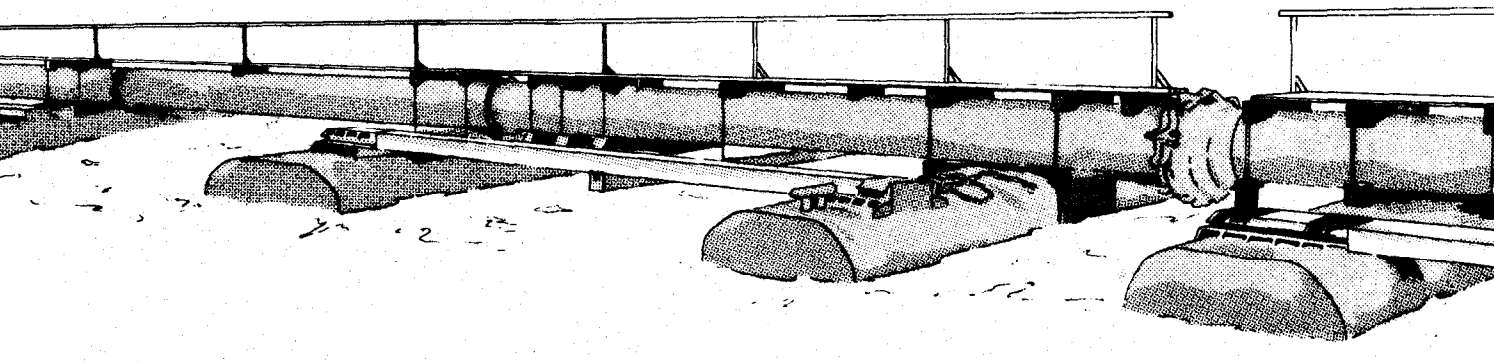
April 1975

Final Report



Prepared for Office, Chief of Engineers, U. S. Army
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Under DMRP Work Unit IA05

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29 July 1977

SUBJECT: Transmittal of Miscellaneous Paper D-75-13

TO: All Report Recipients

1. The miscellaneous paper transmitted herewith represents the results of a multidisciplinary research planning effort undertaken as part of Task 1A, Aquatic Disposal Field Investigation (ADFI), of the Corps of Engineers Dredged Material Research Program (DMRP). Task 1A is part of the Environmental Impacts and Criteria Development Project (EICDP), which has as a main objective the determination of the magnitude and extent of effects of aquatic disposal sites on organisms and the quality of surrounding water, as well as the rate, diversity, and extent such sites are recolonized by benthic flora and fauna.

2. The EICDP includes the conceptualization, planning, and conducting of research to determine the magnitude and extent of the effects of open-water dredged material disposal on water quality and biota and the development of defensible and implementable regulatory criteria. The focal point of the ADFI research is a large-scale, interdisciplinary, field investigation program at existing disposal areas in the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Great Lakes. This report outlines the basic rationale and general, physical, chemical, and biological approaches that were used in the research conducted at each of these sites.

3. This report was originally published as a limited uncirculated edition of an internal working document. It was used as a general guide for development of detailed research plans and scope of work preparation. It is being reprinted for wider circulation as a companion report to the recently completed Task 1A field investigation.

4. The field research program was divided into three phases. Phase I was the period in which the definition and delimitation of baseline environmental conditions were determined for the study area and the establishment of reference areas for comparison purposes was made. The effects of disposal were investigated during Phase II under experimental, controlled conditions. Phase III was a period of compiling results, making evaluations, and formulating recommendations. Specific activities

occurring in each of the three phases and the general duration of each period are described. Specific parameters to be investigated are given. Somewhat comparable data are to be generated at all study areas. A computerized data storage and retrieval system has been established at WES for the reception of these data.

5. Results of the DMRP field research program will include problem identification and delimitation and will establish within what limitations it is possible to predict impact and recovery if background information is given for the disposal site and the material to be disposed in it. This intensified planning effort can act as guidance for field elements preparing field monitoring programs of any size for the evaluation of open-water discharges.

JOHN L. CANNON
Colonel, Corps of Engineers
Commander and Director

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The Aquatic Disposal Research Project (ADRP), as part of the Dredged Material Research Program at the Waterways Experiment Station, includes planning and conducting research to determine the magnitude and extent of the effects of open-water dredged material disposal on water quality and biota. The focal point of the research is a large-scale, interdisciplinary, field investigation program at four existing disposal areas in the Atlantic, Pacific, Gulf of Mexico, and Lake Erie. This report outlines the basic philosophy and general approach (Continued)

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20. ABSTRACT (Continued)

that will be used in the research being conducted at each of these sites. The field research program is divided into three phases. Phase I is the period in which the definition and delimitation of baseline conditions will be determined for the study area and the establishment of a reference area for comparison purposes will be made. The effects of disposal will be investigated during Phase II under experimental, controlled conditions. Phase III will be a period of compiling results, making evaluations, and formulating recommendations. Specific activities occurring in each phase and the actual duration of each period are described. Specific parameters to be investigated are given. Comparable data will be generated at all study areas. A computerized data storage and retrieval system has been established at WES for the reception of these data. Results of the field research program will include problem identification and delimitation and will establish within what limitations it is possible to predict impact and recovery if background information is given for the disposal site and the material to be disposed in it.

PREFACE

Under the authority contained in Section 123(i) of Public Law 91-611, the Corps of Engineers is conducting a comprehensive research program concerning the disposal of dredged material. The Environmental Effects Laboratory (EEL) of the U. S. Army Engineer Waterways Experiment Station (WES) has been assigned the responsibility for program planning, management, and research accomplishment, which has been designated as the Dredged Material Research Program (DMRP).

One of the many problems being addressed by the DMRP is the adequate definition of the environmental impact of the disposal of dredged material in open water. This problem will be addressed through interdisciplinary field research at four disposal sites with one located in each of the following coastal areas: Atlantic, Pacific, Gulf of Mexico, and Lake Erie. This report outlines the basic philosophy and general approach that will be used in the research accomplishment at each of the study sites.

This report was prepared by Dr. Paul R. Becker, Mr. Barry W. Holliday, Ms. Susan E. Palmer, and Dr. Robert M. Engler of the Aquatic Disposal Research Project, under the general supervision of Dr. John Harrison, Chief, EEL.

Directors of WES during the development and publication of this report were BG E. D. Peixotto, CE, and COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

GENERAL RESEARCH PLAN FOR THE FIELD INVESTIGATIONS OF COASTAL DREDGED MATERIAL DISPOSAL AREAS

PART I: BACKGROUND

1. In the 1970 River and Harbor Act, Congress authorized the Corps of Engineers to initiate a comprehensive nationwide study to provide more definitive information on the environmental impact of dredging and dredged material disposal operations and to develop new or improved dredged material disposal practices. The study was divided into four phases: problem identification and assessment; development of research program; accomplishment of needed research; and field evaluation of new or improved disposal practices. The U. S. Army Engineer Waterways Experiment Station (WES) has been assigned responsibility for the research accomplishment, which has been designated as the Dredged Material Research Program (DMRP).

2. The DMRP is a comprehensive program of research, the planning and implementation of which is being accomplished by an interdisciplinary team established within the Environmental Effects Laboratory (EEL) at WES. The program is developed under four major research projects:

a. Aquatic disposal.

b. Habitat development.

c. Disposal operations.

d. Productive uses.

3. Each research area is subdivided into several research tasks. Within the Aquatic Disposal Research Project (ADRP), there are five research tasks: 1A, Disposal Area Field Research; 1B, Movement of Dredged Material; 1C, Effects of Dredging and Disposal on Water Quality; 1D, Effects of Dredging and Disposal on Aquatic Organisms; and 1E, Pollution Evaluation.

4. The general research plan for Task 1A, Disposal Area Field Research, is presented herein. It is a statement of philosophy and approach that will serve as a general guideline to be followed throughout the program.

PART II: PROBLEM DEFINITION

Introduction

5. The proposed research is an effort to determine the magnitude and extent of the effects of open-water dredged material disposal sites on organisms and the quality of surrounding water and the rate and extent of recolonization of such sites by benthic communities. Because of the lack of information concerning the effects of present disposal procedures, this research is concerned primarily with the determination and evaluation of the short- and long-term environmental effects in known coastal disposal areas.

6. Due to seasonal variations and the subtle nature of changes in benthic communities, onsite, long-term investigations are needed to adequately document and assess cause-and-effect relationships. In order to evaluate these changes and cause-and-effect relationships, a large-scale research program will have to be conducted on the sites and on the surrounding areas with the purpose of studying natural and unnatural changes in the surrounding sediment regime and water column, as well as in the associated flora and fauna of each.

Preliminary Studies

7. Due to the high cost of such an effort and the great number and diversity of coastal sites, a preliminary survey of all known open-water coastal disposal sites has been conducted. The survey resulted in an inventory of all currently available information pertinent to the coastal disposal of dredged material. The inventory was then used to select specific sites and to design the field studies that will be conducted at the sites.

8. An assessment has been made of those physical, chemical, and biological factors currently thought to serve as indices of, or control of, benthic colonization. The latest monitoring equipment, methodologies, and institutional capabilities pertinent to the research task

have been determined and catalogued. A computerized information storage and retrieval system has been developed and will be used in the program implementation.

Data-Gathering Plan

9. The areas selected for study are those thought to be most representative of open-water disposal in the Pacific, Atlantic, Gulf of Mexico, and the Great Lakes areas. The information storage and retrieval system that has been set up at WES will be considered as a Data Center for all study areas; therefore, a continuous feed of data from these areas to the center is anticipated. In order to implement such a system and also in order to evaluate recolonization patterns and cause-and-effect relationships on a general and nationwide scale, it will be necessary to have comparable data generated from all areas. This requires that a general concept or plan of research be formulated and that certain specifications will have to be made on the particular techniques and equipment to be used in these studies and the specific format for data received at the Data Center.

10. All data gathering will be performed on a contract basis by those investigators in the area (universities, commercial firms, and Federal or State agencies) that have the expertise to do the particular part of research needed. Investigators located near the study sites have the best knowledge concerning those peculiarities inherent to the region; therefore, in the early stages of the research effort, the contractors will have definite input into specific modifications of the basic research plan. This will be necessary to ensure that the data generated from that particular region will be meaningful.

General Approach

The research program

11. In order to identify the cause-and-effect relationships due to disposal and to distinguish these from other relationships within the

study area, some type of control or reference area will have to be established outside each disposal site. This will be an area relatively unaffected by the disposal but as close to the site as possible, with a benthic assemblage characteristic of the general area, and relatively unaffected by any type of external stress, either man-made or peculiar for the region that is being characterized. Water-quality parameters, current patterns, sedimentary dynamics, and faunal assemblages will have to be known for each disposal site and control area. Therefore, for disposal sites and surrounding areas where these data are lacking, baseline data will have to be gathered.

12. To accomplish this task, the research program was divided into Phases I, II, and III. During Phase I, baseline information will be generated and information on seasonal variability will be obtained. This phase of the program is visualized as a dynamic one in which baseline data will be gathered, initial sampling schemes will be refined for as much statistical validity as possible (number of stations, placement of stations, number of replications, etc.), and any changes in methodology or techniques that have to be made will be identified. Areas for the disposal of dredged material will be established in order that a control of frequency of disposal, type of material dumped, and type of bottom disposed on can be established within the limitations of the disposal site or sites.

13. Phase II, which will be a continuation of data gathering and will incorporate all changes deemed necessary from Phase I, will continue for the duration of the study (three years). Phase III will consist of the compilation and evaluations of results and the formulation of recommendations.

14. Relative to the disposal operations, the investigation should be considered as divided into three parts: investigations before, during, and after disposal operations. The intensity of the measurement of environmental parameters will vary relative to these three parts of the investigation.

Areas and parameters of study

15. The following areas and parameters are to be investigated.

Figure 1 shows the proposed sampling program.

a. Air-water interface. Meteorology data-gathering at the air-water interface will be continuous and more or less of the same intensity before, during, and after disposal operations.

b. Water column. Physical, chemical, and biological parameters will be determined; intensity of data-gathering should increase during and immediately after the disposal operations.

c. Near-bottom water. Physical, chemical, and biological parameters will be determined at the sediment-water interface; intensity of data-gathering should increase immediately after the disposal operations.

d. Bottom. Physical, chemical, and biological parameters will be determined; intensity of data-gathering should increase immediately after disposal operations.

16. In specifying methodologies, techniques, and equipment, the use of automated data-collection systems and combined sampling packages (such as devices that combine bottom grabs or box corers, water corers, thermistors, and oxygen probes into one sampling apparatus) will be stressed.

Supplementary and related studies

17. Although many cause-and-effect relationships will be established during these long-term studies, some problems will be identified that require either laboratory investigations using controlled conditions or intensive short-term field studies in which partial control of certain environmental parameters can be attained. These particular research task areas will be initiated either at WES or under separate contracts as the specific problems are identified in the field. By supplementing the long-term studies with laboratory and short-term field studies as needed the maximum amount of information can be derived from each study area.

18. In order to obtain a more complete picture of related problems and environmental variations and trends in each geographical region, it is the policy of WES to maintain close contact with other investigators in that region who are involved in related environmental research.

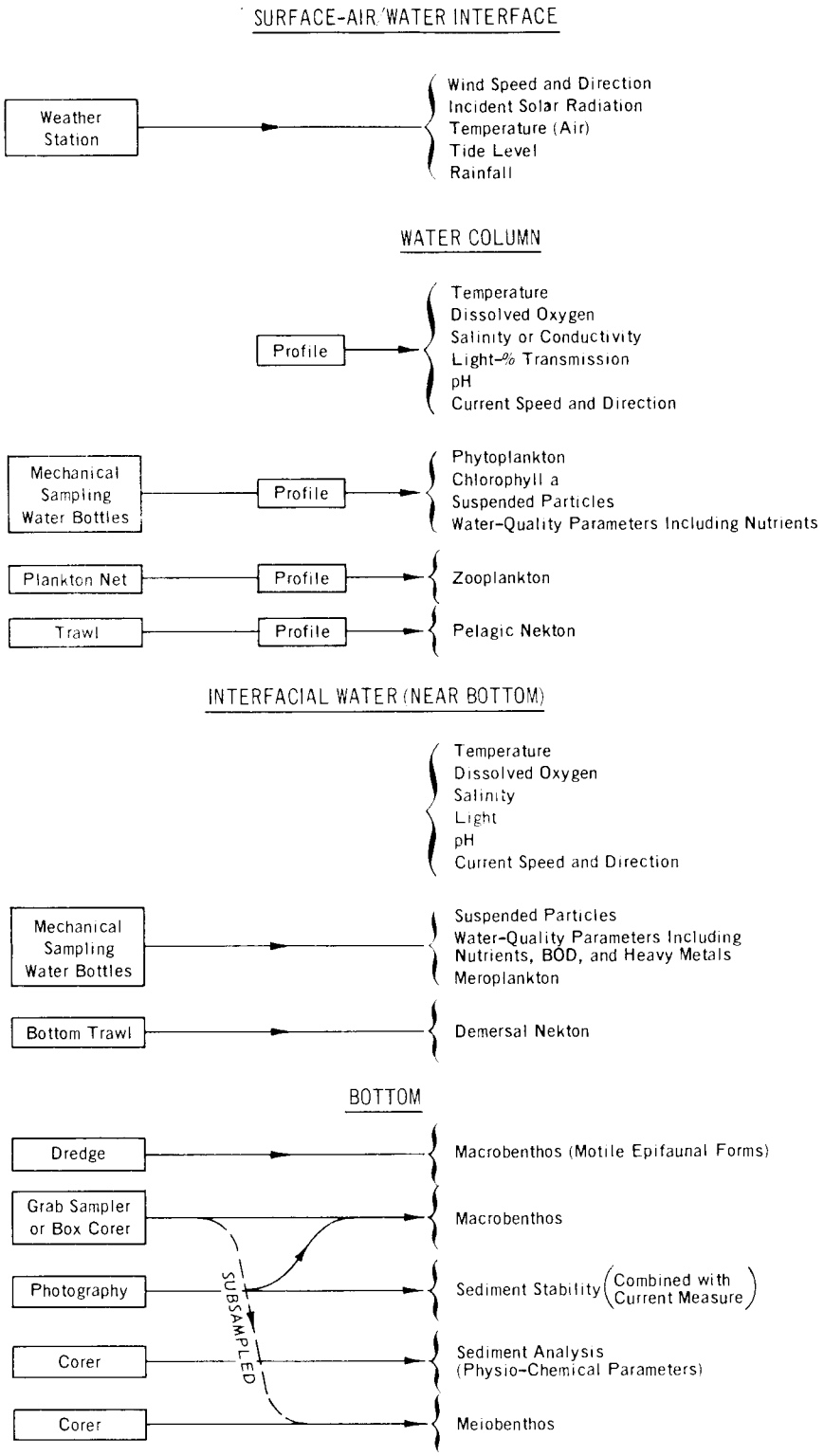

Figure 1. Proposed sampling program

PART III: GENERAL RESEARCH PLAN

19. The research program is developed around four key elements that are essential to meet the objectives of the long-term field studies. These elements are: definition and delimitation of the baseline conditions; establishment of a control or reference area; evaluation of the effects of experimental controlled disposal; and the careful coordination of laboratory and short-term field studies with the long-term field studies (Figure 2). Each of these items will be discussed in detail below.

20. In order to facilitate the planning and implementation of the research, the program is divided into three phases. Phase I is considered the pilot phase and will last approximately one year (FY 75). Phase II will be the main experimental phase, running through FY 76 and FY 77. Phase III will continue for the most of FY 78 and will be a period consisting of the conclusion of research, compilation and evaluation of results, and the formulation of recommendations. As each phase is described, it will be apparent that each is not mutually exclusive. There will be no real points in time dividing one from the other, but there will be a subtle transition from one phase to the next. This is particularly true of Phases II and III. Figure 3 gives the time scales of each phase relative to the four key elements.

21. Although the evaluation of the research will continue throughout the program, in order to ensure that the program is proceeding in the right direction, specific points in time have been designated for more formal critical evaluation by WES personnel and the contractors involved. These evaluation points will be scheduled annually.

Phase I

General plans

22. The first year's effort (FY 75) at the field study sites is termed Phase I. The basic objective of Phase I is to gather baseline data on the disposal site and the surrounding area. Specific parameters

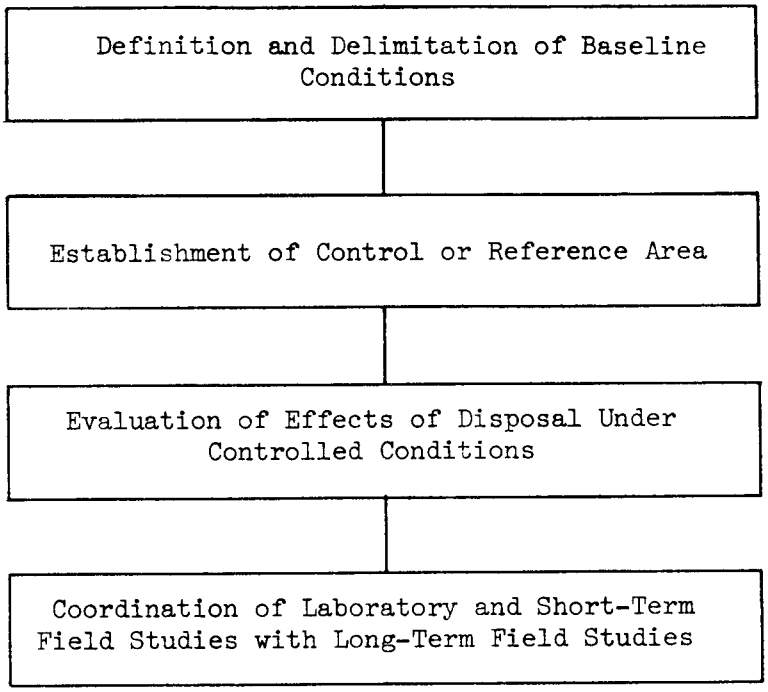

Figure 2. Four key elements essential to implementation of the research program

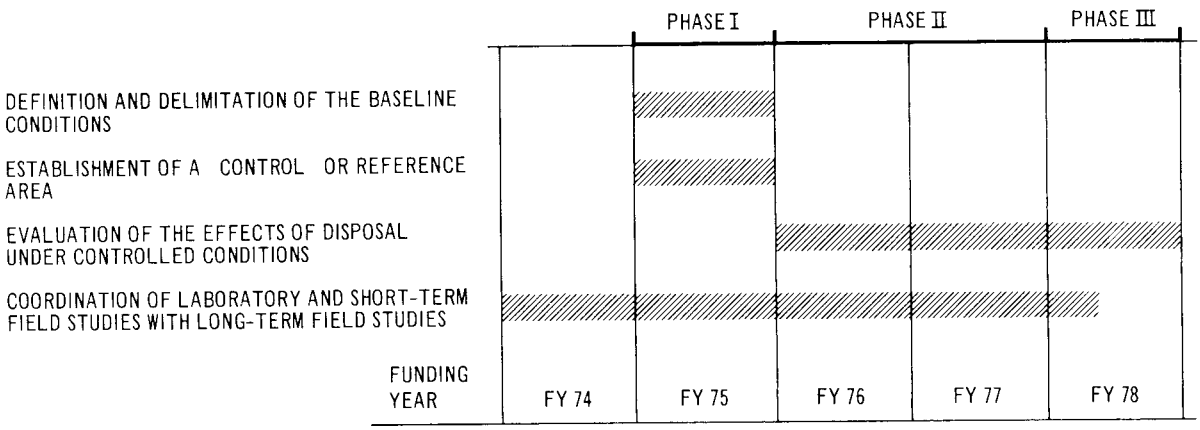

Figure 3. Schedule for research program

that are to be measured are given in Table 1. These data will be used to establish seasonal variation, establish controlled disposal sites and reference control areas outside the disposal sites, and establish permanent data-gathering stations within each site (Figure 4). During this period, data will be gathered on the general morphometry and physical dynamics of the study area, meteorological conditions, water-quality parameters, physiochemical characteristics of the sediments, and basic biological parameters.

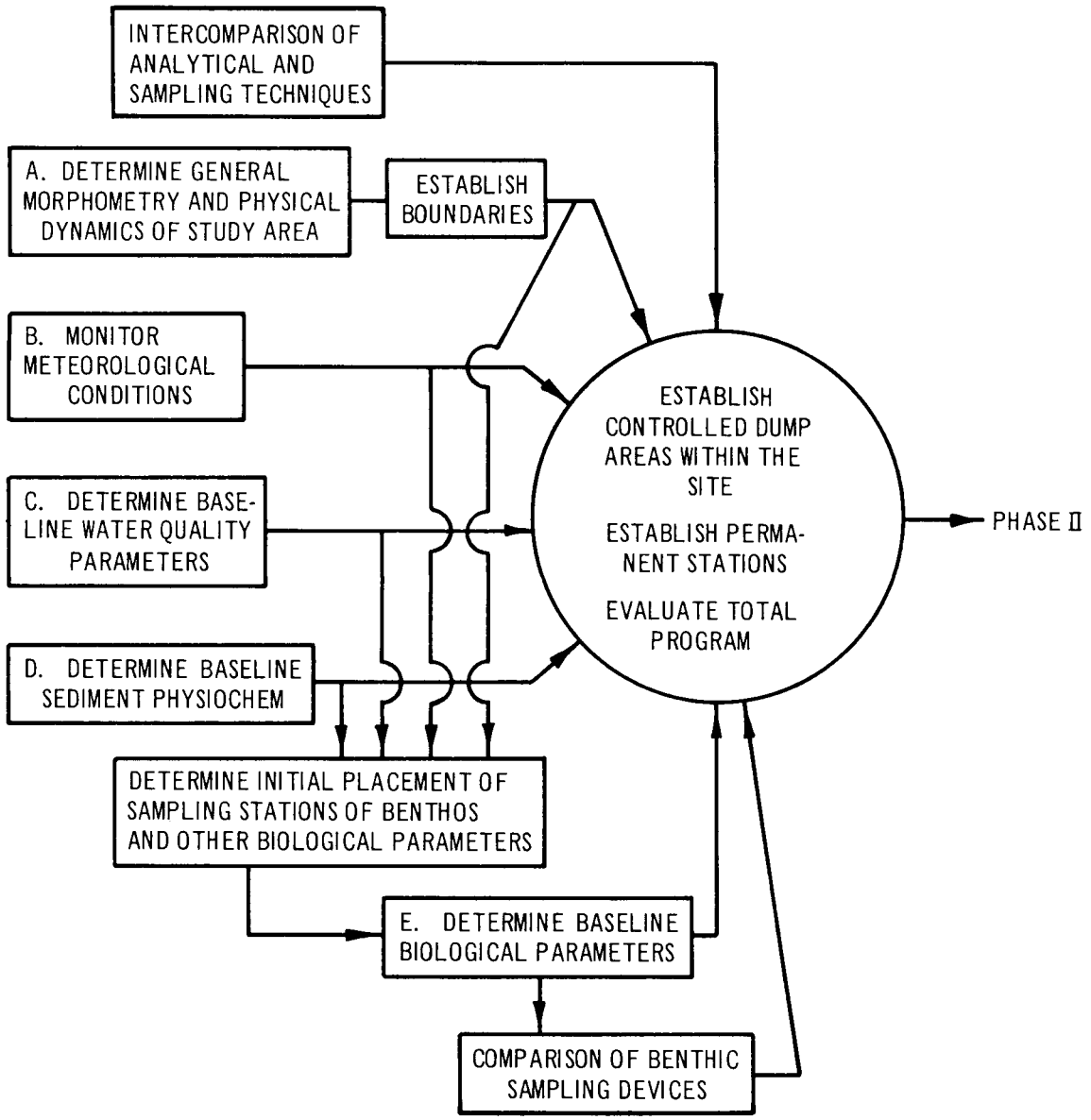

Figure 4. Flow diagram for Phase I (FY 75)

23. Phase I will be a dynamic period in which field comparisons will be made of sampling devices and spatial as well as temporal variability will be defined. This information will be used to refine the initial sampling scheme for as much statistical validity as possible. Changes in methodologies or techniques that have to be made will also be identified. Near the end of Phase I and before the establishment of controlled dump sites, an extensive evaluation of the total field program will be made.

Specific parameters

24. The parameters in Table 1 are grouped under general headings that correspond to blocks A, B, C, D, and E of the flow diagram for Phase I (Figure 4).

25. General morphometry and physical dynamics. One of the first tasks to be initiated at each study area will be the determination of the general morphometry from bathymetric surveys, sediment mapping, sediment transport studies, and the documentation of current velocity profiles and circulation patterns. The preliminary information resulting from this task will be used to guide the establishment of water-quality, sediment-quality, and biological sampling stations within the study area. The temporal variation of the hydraulic regime will be investigated throughout Phase I.

26. Meteorological conditions. The meteorological conditions in the area will be monitored concurrently with the investigations of the physical dynamics, water- and sediment-quality conditions, and biological communities. The frequency of data-gathering and observation relative to each of these investigations (A, B, C, D, and E) will be dependent on natural phenomena, such as storms, high river discharge, periods of unusual weather, or water column stability.

27. Baseline water-quality parameters. The water-quality parameters listed in Table 1 are those that are considered to have a definite relationship to aquatic biological communities and/or have a potential for being affected by dredged material disposal in open water. Effects of disposal will probably be of an acute nature in the upper water column with possible chronic effects associated with the water column just

above the bottom (interfacial water). The latter may reflect changes in the quality of the sediment. The actual degree of the effects, if any, of dredged material disposal on the upper water column or the interfacial water will depend on depth and the current regime as well as the nature of the dredged material itself.

28. Any effect on water quality due to dredged material disposal will have to be viewed in its correct perspective relative to natural seasonal variations; therefore, a sampling program will be established to follow temporal variation in water quality throughout Phase I.

29. Baseline sediment physio-chemistry. That portion of the aquatic ecosystem that has the greatest potential for being affected by dredged material disposal and also the greatest potential for having a long-term impact on the biota, particularly the benthos, is the bottom sediment. The form of the bottom sediment is actually a composite of several chemical, physical, and biological factors associated with the sediment particles. These can be related to the potential habitat and shelter, food, or the presence of toxic materials.

30. There is a close relationship between organic matter, the mechanical nature of the sediments, and the feeding habits of the benthic organisms. Particle-size distribution, particle density, and percent water all determine potential habitat and shelter by affecting the compaction and stability of the bottom, and its suitability for various types of epifauna or infaunal burrowing forms.

31. Living and nonliving organic materials, including both dissolved and particulate forms, serve as a food source for deposit-feeding organisms. The relative amounts of these materials can directly affect the number of such organisms that can be supported by a particular area of the bottom.

32. The release of toxic substances that are associated with sediment particles, such as heavy metals, is directly related to the sorptive properties of the particles. The availability of heavy metals and the potential release of ammonia, hydrogen sulfide, and nutrients to the water column are directly related to the chemical properties of the substances themselves and the redox potential, pH, and the

cation exchange capacity of the sediments.

33. Baseline sediment chemistry investigations will involve both total sediment analysis and interstitial water analysis (Table 1). Theoretically, various substances associated with the interstitial water have a greater potential for influencing water quality and affecting the biota associated with the sediment.

34. Although the field studies are directed toward defining the effects of disposal on benthic organisms, the organisms of the water column and the benthos are closely related in the functioning of the entire aquatic system. Therefore, any study of the benthos will require that some attention be given to the nekton and plankton. This becomes obvious when one considers that plankton may serve as a food source for benthos, that most marine benthos have planktonic larvae for dispersal, that members of the zooplankton and nekton may be important predators of the planktonic larvae of the benthos, and that many important predators of the benthos are nektonic (particularly demersal fish). Another important aspect is the effect of disposal operations on the spawning and nursery ground of commercially important fish, which involves not only study of the nekton but also their planktonic eggs and larvae.

35. During Phase I, the structural and functional components of the benthic, planktonic, and nektonic communities will be described both spatially and temporally (Table 1), and the relationship between these communities determined. Benthic investigations will be directed toward the macro- and meiobenthos. In the case of the latter, the emphasis will be on the meiobenthic larval stages of the macrobenthos.

36. Investigations of the benthos will include the analysis and comparison of the efficiency and effectiveness of quantitative, semi-quantitative, and qualitative sampling devices. Quantitative grab and box corer sampling devices will be compared as to depth of penetration, volume of material retrieved, species selectivity, and ease of operation as a function of sediment type. Statistical validity and sampling error of quantitative sampling devices will be determined, as will the number of replicate samples needed to provide statistically valid data.

37. Within the phytoplankton community, attention will be given

to the estimation of primary productivity and enumeration on a seasonal basis, in order to determine numerically dominant forms and those forms that have a potential for creating water-quality problems.

38. Investigation of the zooplankton community will involve the evaluation of holoplanktonic forms that may be important links in the pelagic food chains, and the evaluation of meroplanktonic forms that (a) may be important seasonal links in the pelagic food chains; (b) may give indications of the reproductive seasons of the benthos and also indication of the potential for recolonization of the benthic community; and (c) may provide data for the reproductive seasons of finfish and give indications of spawning and nursery grounds for the commercially important forms and those that are predators of the benthos.

39. With the above objectives in mind, evaluation will include enumeration at the species level and age class analysis where practical. The major emphasis of the nekton will be placed on spatial and temporal distribution patterns and food chain relationships with the benthos.

40. Toward the end of Phase I and before the initiation of the controlled disposal operations of Phase II, an effort will be devoted to defining the baseline levels of specific contaminants within the resident benthos. Selected samples of benthic organisms from the study area will be analyzed for levels of heavy metals and chlorinated hydrocarbons. Based on the food chain relationships established during Phase I, selected species of demersal nekton will also be surveyed for contaminant levels. These data will be related to existing levels established by the previously discussed sediment-quality investigations and will also be related to any changes due to dredged material disposal documented during Phase II.

Literature survey

41. A literature survey will be conducted concurrently with the research project on all available physical, chemical, and biological data within the study area and within the regional area of concern (Long Island Sound, Northwest Pacific, etc.). The primary objective of this survey will be to evaluate to what extent possible cause-and-effect relationships derived from the field studies can be applied, in terms of

predictive capability, to each region.

Phase II

42. The primary effort of the research program will take place during Phase II (FY 76 and 77). The general objective of Phase II will be to evaluate the effects of open-water disposal of dredged material under controlled disposal conditions. More specific objectives will include documentation of effects and delimitation of the importance of each parameter in order to gain insight into the degree to which one can predict cause-and-effect relationships.

43. The actual attainment of these objectives will involve the establishment of experimental, controlled disposal procedures and the evaluation of cause and effects relative to baseline conditions before disposal and to concurrent conditions in the reference area. It will also involve the careful coordination of laboratory and short-term field studies with multivariate analysis of long-term field data.

44. The flow diagram in Figure 5 is a continuation of Figure 4 and, on a relative time scale, predicts the sequence of events that will occur during Phase II. It begins with controlled disposal procedures, as outlined in the subsection below, and will continue with the constant measurement of the meteorological, hydraulic, water and sediment quality, and biological parameters established during the baseline studies of Phase I. The analysis of the field data, as well as the testing of various community succession models established during Phase I, will continue throughout the program. Laboratory and intensive short-term field studies will be initiated as the field results identify various areas that need more extensive study.

45. The research effort illustrated in Figure 5 represents the sequence of events occurring for FY 76. These events will continue during FY 77 with the evaluation of the total program occurring at the end of FY 76 and FY 77.

Establishment of controlled disposal sites

46. Inherent in the research program will be the establishment of

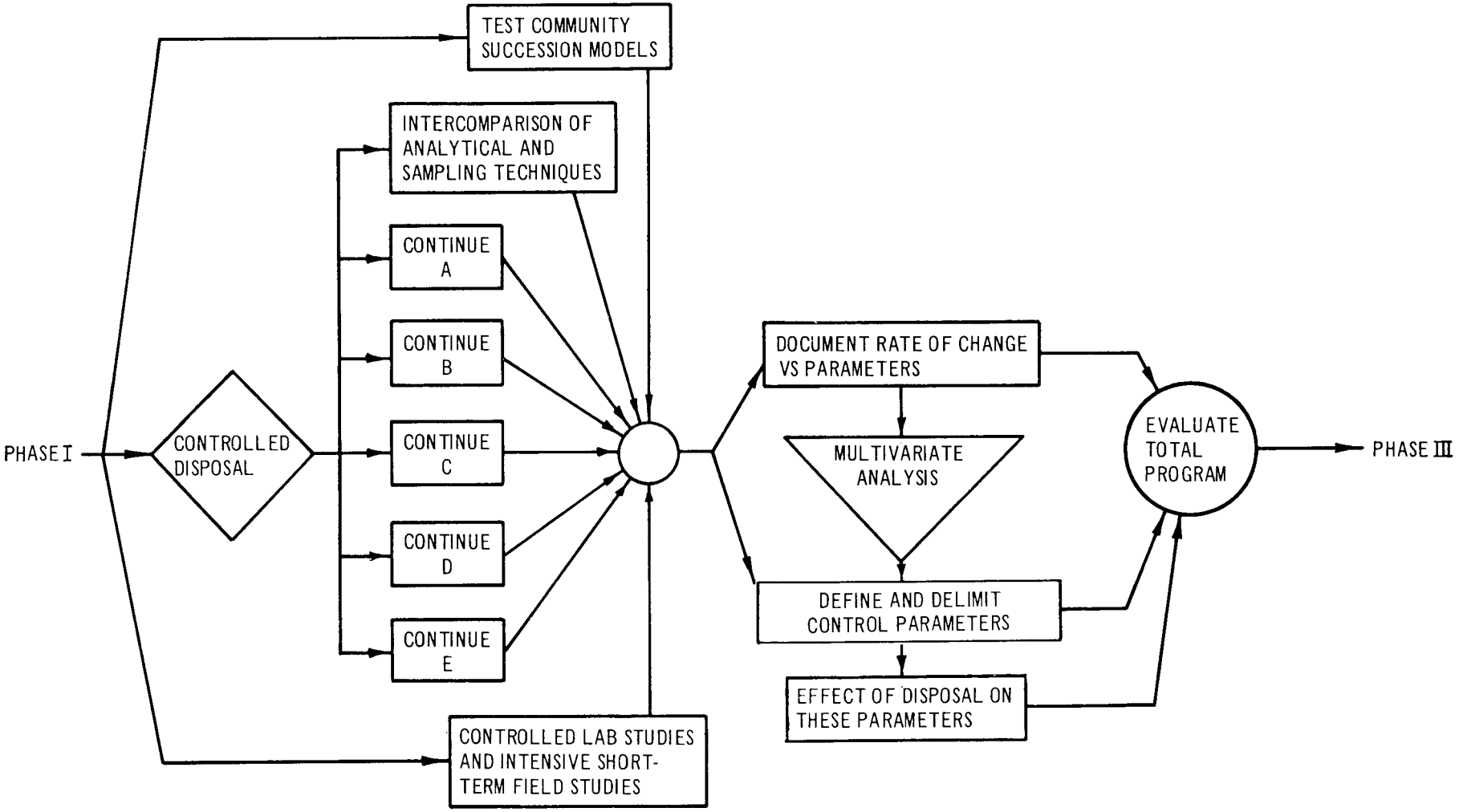

Figure 5. Flow diagram for Phase II (FY 76-77).
Continuation of Figure 4

a control on disposal procedures. This control is directed toward three variables: (a) type of bottom in disposal area; (b) type of material disposed; and (c) amount and frequency of disposal.

47. Type of bottom. From information compiled during Phase I, diversity of sediment types, sedimentary dynamics, water-quality parameters, current patterns, and distribution patterns of faunal assemblages will be established. This information will be used in selecting specific sites within the study area for the disposal of previously selected dredged material. The actual number of these experimental sites will depend upon several factors including the size of the disposal area, the diversity of sediments in the disposal area, and the diversity of sediments that can be disposed of in the study area. The placement and marking (by buoy markers or other feasible means) will be accomplished by WES in conjunction with the CE District and contractors involved.

48. Type of dredged material. The sediment to be dredged and to be placed in a particular experimental site will be analyzed before disposal operations using the specifications established for sediment analysis for the research program. The actual placement will be determined by WES in conjunction with the CE District and contractors. The contractors will work closely with the ADRP site manager and will be ready to take samples on relatively short notice. This will be necessary due to the short time between the analysis of the sediments to be dredged and time of dredging and disposal. The contractor will be informed as soon as possible after the analysis about the pending disposal in a particular point-dump site.

49. Amount and frequency of disposal. The amount of material to be disposed of and frequency of disposal in a particular experimental site will be determined by WES in cooperation with the CE District and contractors. At no time will the amount dumped be more than is needed at the experimental site. If a dredging operation consists of more material than is needed at the site, the excess will be diverted elsewhere. The study area will never be considered as a convenient dump during the course of the research, and only the material necessary for completion of the study will be placed there. The general plan of

establishing these controlled experimental disposal sites is shown schematically in Figure 6 using a simple, hypothetical site.

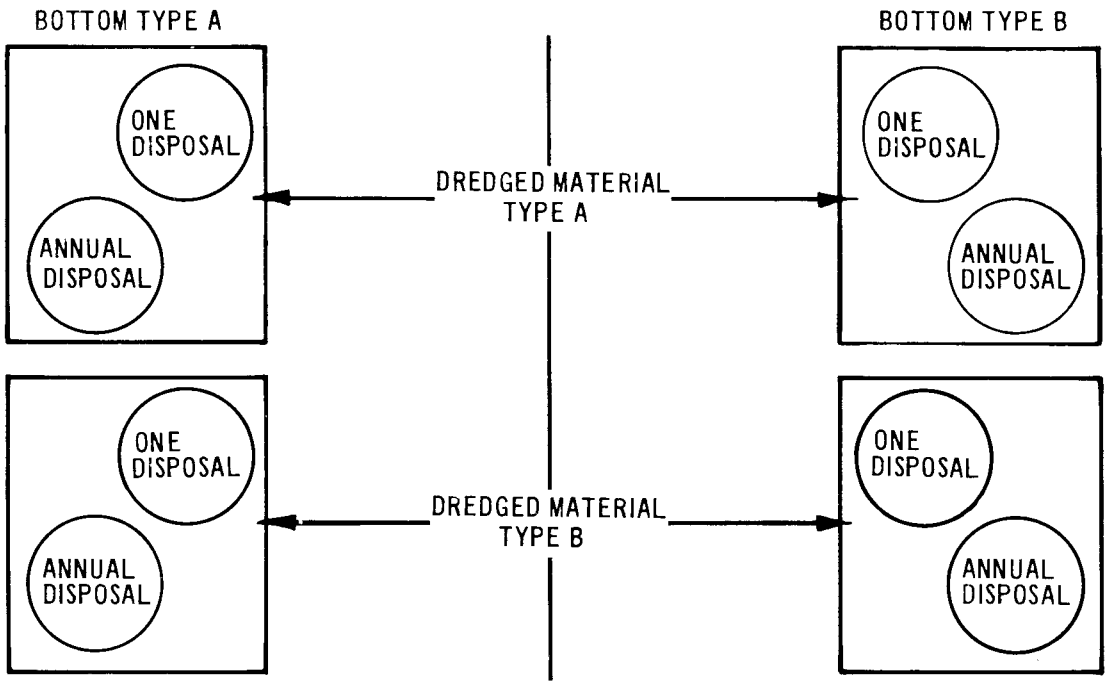

Figure 6. Experimental sites for controlled disposal of dredged material

Laboratory and short-term field studies now under way

50. Although laboratory and short-term field studies will be initiated as the findings of the long-term studies dictate, there are several specific problems that have already been identified and for which research has already been initiated using the controlled conditions of the laboratory. This research is divided into two areas: (a) the effects of dredging and disposal on water quality and (b) the effects of dredging and disposal on aquatic organisms.

51. During FY 74, five laboratory studies were initiated to determine the effects of dredging and disposal on water quality. The first effort will determine what factors control chemical migration of various elements and compounds from the aquatic phase to the solid phase and vice versa in aquatic sediments. The other studies are determination of the direct and indirect effects of sediment organic fractions on the migration and bio-availability of various contaminants during dredging

and disposal; a survey of the release of pesticides into the water column during dredging and disposal; the evaluation of the effects of Eh, pH, and dissolved oxygen on chemical migration during disposal; and the determination of the effect of dispersion, settling, and resuspension on chemical migration during disposal.

52. Two laboratory studies investigating the effects of dredged material on aquatic organisms were initiated in FY 74. The first will determine the vertical migration ability of various forms of macrobenthic organisms in various depths of deposits of different types of dredged material. The second will determine the availability of sediment adsorbed pesticides to benthos, with particular emphasis on deposit feeding infauna. Also initiated, was the application of simulated ecosystem modeling to dredged material research. Within the realm of the short-term field studies, one research effort was initiated to elucidate the role of life-history stages of various forms of benthos for potential recolonization of dredged material disposal sites. Two laboratory studies are being funded for FY 75: the response of selected aquatic organisms to suspended dredged material; the comparison of geographical races; and the availability of sediment-adsorbed heavy metals to benthos, with particular emphasis on deposit-feeding infauna.

Phase III

53. Phase III of the research program will involve the compilation and evaluation of results and the formulation of recommendations. Information from the field and laboratory studies and information from related dredged material studies will be analyzed. Final relationships, effects, and conclusions will be documented. The resulting evaluations and recommendations are the primary objectives of Phase III and will be basic contributions to the overall goals of the ADRP and DMRP.

54. The results of Phase III are related to three levels of need (Figure 7). The immediate results are related to specific goals of the ADRP. These results in turn contribute to the basic goals of the DMRP. The recommendations and information resulting from the entire DMRP then

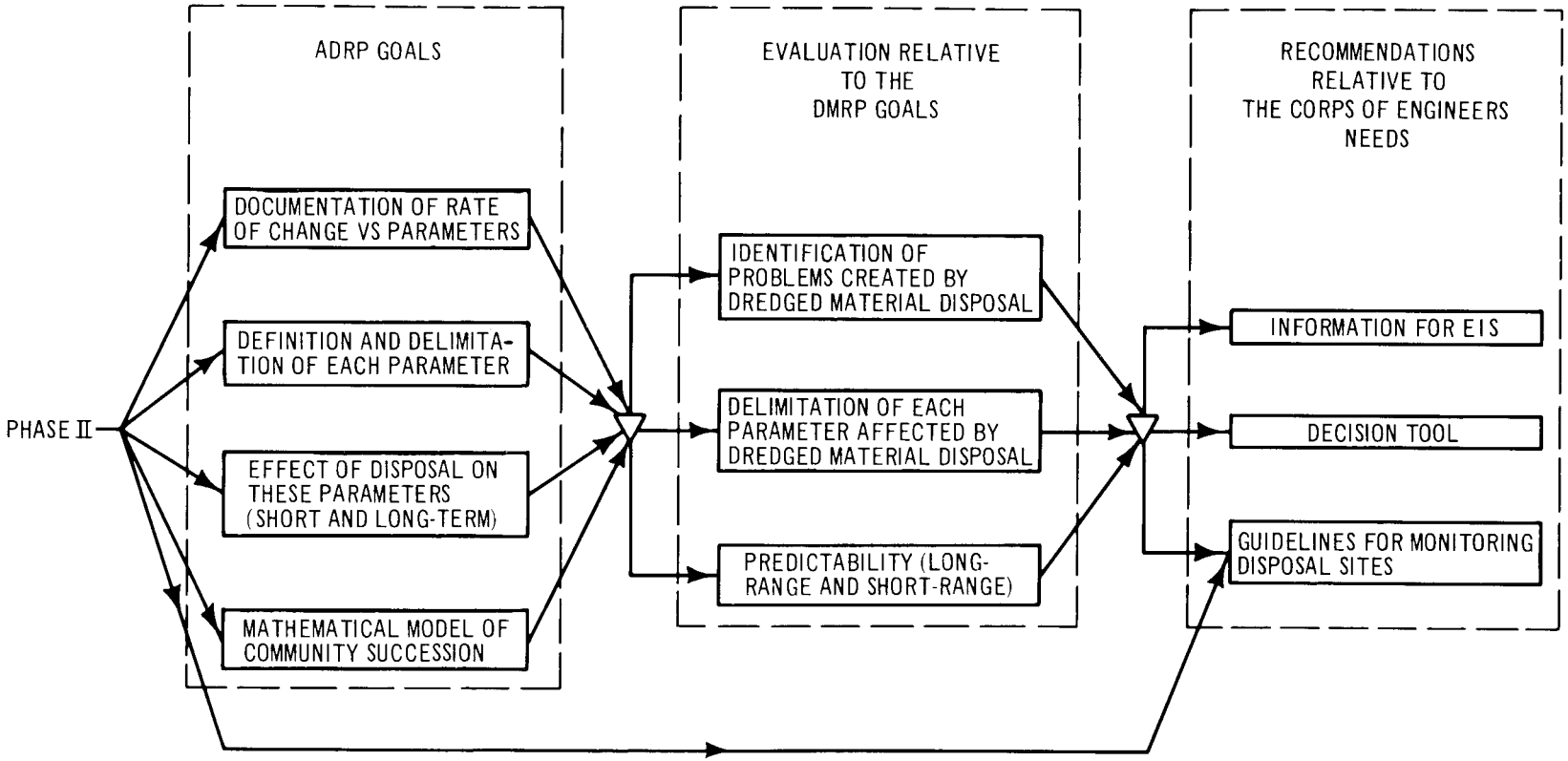

Figure 7. Flow diagram for Phase III (FY 78).
Continuation of Figures 4 and 5

provide for the immediate needs of the Corps of Engineers in general.

Application to ADRP goals

55. The immediate results of the research program will satisfy the following specific goals of the ADRP.

a. Documentation of the rate of change versus parameters. Documentation will include changes occurring immediately after disposal in water quality and sediments, pelagic and planktonic communities, and benthic communities, as well as changes occurring during recovery of the disposal sites.

b. Definition and delimitation of each parameter. Those parameters that are affected by disposal will be defined and delimited.

c. Effect of disposal on each parameter. The importance of each parameter in determining the direction and rate of change after disposal, the rate of recovery if it occurs, and the point at which equilibrium is established will be determined.

d. Mathematical community succession modeling. Various community succession models will be evaluated to establish the usefulness of such models for the prediction of benthic recolonization of dredged material disposal sites.

Application to DMRP

56. Evaluation of the immediate results of the ADRP will contribute to the basic aims of the DMRP. Problem identification and delimitation will involve defining what parameters are involved (total) and to what degree each is involved, i.e., which are the most important or selective. Predictability of the problems involves answering the basic question, "Within what limitations is it possible to predict impact and recovery given background information for the disposal site itself and what will be disposed in the site?" Also, in the case of old disposal sites in which the impact is obvious and appears to be lingering, what type of new disposal would aid in either site recovery or a more acceptable level of organization.

District and Division use

57. With the basic field parameters determined and a predictive capability established, the Corps of Engineers Divisions and Districts will have useful tools to apply to other open-water disposal-site

decisions. Parameter delimitation and predictability will provide a basic tool for considering parameters to be evaluated in the writing of environmental impact statements as well as a tool for decision of how to dispose, what to dispose, and where. In the case of "where to dispose," and within the context of open-water disposal only, the long-term field studies along with their coordinated short-term field studies and laboratory studies will not completely answer all questions concerned. However, taken within the context of the entire DMRP, this effort should be an important link in considering the alternatives in dredged material disposal.

58. The last item, which will be of additional importance to the Corps Divisions and Districts, is the development of guidelines for future monitoring of disposal sites. Those parameters most important in the cause-and-effect relationships of dredging and disposal will be delimited in order that future monitoring programs operate at the highest level of efficiency for the least amount of investment, to yield the largest amount of information.

Table 1

Specific Parameters to be Measured at the Study Areas During Phase I

Parameters	Measurements
A. Determination of the general morphometry of the study area and the establishment of boundaries of disposal and reference or control areas	Bathymetry Current velocities and patterns (vertical profile) Sediment distribution and transport
B. Monitoring of meteorological conditions	Wind direction and speed Tide heights* Lake levels** Wave activity Rainfall Air temperature Incident solar radiation
C. Determination of baseline water-quality parameters. Vertical profile with concentrated efforts on water column just above the bottom	Temperature Dissolved oxygen Salinity* Conductivity** pH Alkalinity** Nutrient levels: Nitrate - N Nitrite - N Ammonium - N TKN Ortho - PO_4 Total - P Silicate Dissolved organic - C

(Continued)

* Marine only.

** Fresh water only.

Table 1 (Continued)

Parameters	Measurements
C. Determination of baseline water-quality parameters. Vertical profile with concentrated efforts on water column just above the bottom (Continued)	Heavy metals Chlorophyll and related plant pigments Suspended particles: Particle size distribution and concentration Organic fraction Associated heavy metals Light transmission
D. Determination of baseline sediment physiochemistry	Total sediment analysis: Particle size distribution X-ray diffraction analysis Eh and pH Total sulfide Percent water Total organic - C Total organic - N Ammonium Total - P Cation Exchange Capacity Oil and grease Trace metals (Fe, Mn, Hg, Cd, Cu, Ni, Pb, and Zn) Chlorinated hydrocarbons Interstitial water analysis: Total organic - C (dissolved) TKN Nitrate - N Nitrite - N Ammonium - N Ortho - PO_4 Trace metals (Fe, Mn, Hg, Cd, Cu, Ni, Pb, and Zn)

(Continued)

Table 1 (Concluded)

Parameters	Measurements
E. Determination of baseline biological parameters	Benthos - changes in types, abundance, and distribution patterns: Macrobenthos Meiobenthos Phytoplankton - changes in types, abundance, and distribution patterns Zooplankton - changes in types, abundance, and distribution patterns Nekton (particularly demersal) - changes in types, abundance, and distribution patterns Baseline levels of contaminants in the biota: Heavy metals Chlorinated hydrocarbons

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Becker, Paul R

General research plan for the field investigations of coastal dredged material disposal areas, by Paul R. Becker, Barry W. Holliday, Susan E. Palmer [and] Robert M. Engler. Vicksburg, U. S. Army Engineer Waterways Experiment Station, 1975.

23 p. illus. 27 cm. (U. S. Waterways Experiment Station. Miscellaneous paper D-75-13)

1. Coastal environment. 2. Disposal areas. 3. Dredge spoil. 4. Dredged material. I. Holliday, Barry W., joint author. II. Palmer, Susan E., joint author. III. Engler, Robert M., joint author. (Series: U. S. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper D-75-13)

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